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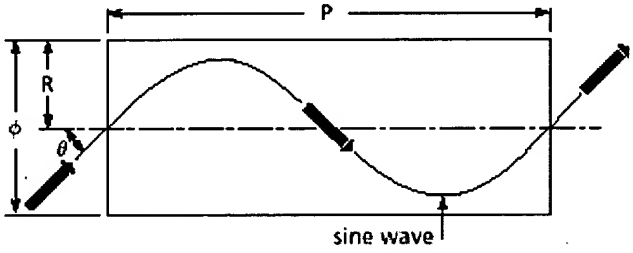
Gradient Index Lenses

Gradient Index (GRIN) lenses combine refraction at the plane dend surfaces with continuous refraction within the rod. Most GRIN lenses are made with SELFOC®, a radial gradient-inde› material. The refractive index of SELFOC material varies parabolically as a function of radius illustration below shows the path of a ray that enters a rod-shaped GRIN lens of diameter ϕ a length P at angle θ.



GRIN lense are well suited to coupling the output of a dode laser into an optical fiber becaus‹ aberration correction can be achieved withoug complex multielement systems or aspherics, ‹ because real images can be formed at the lens surface.

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If you can't find it here, check the Photonics Dictionary!

GRIN lenses

What is a GRIN lens?

GRIN is short for graded-index or gradient index. It refers to an optical element in which the refractive index varies. More specifically (from the Photonics Dictionary) a GRIN lens is a lens whose material refractive index varies continuously as a function of spatial coordinates in the medium. Also, a graded-index fiber describes an optical fiber having a core refractive index that decreases almost parabolically and radially outward toward the cladding.

GRIN lenses come in two basic flavors: RADIAL or AXIAL which are sometimes refered to as RGRIN and AGRIN respectively. RGRINS are usually used where you want to add optical power to focus light. An RGRIN with flat surfaces can focus light just as a normal lens with curved surfaces does. Thin RGRIN lenses with flat surfaces are known as WOOD lenses, named after the American physisist R.W. Wood who did a lot of experimental work with radial gradients from about 1895 to 1905 and included descriptions of how to make them in his physics text book (available from OSA).

Long RGRINS can be used as a high quality image relay. Our company (Gradient Lens Corporation) makes EndoGRINS relays for industrial borescope and medical endoscope applications. These can range in diameter from 0.5 mm to 5 mm in lengths from 50 mm to 300 mm. Image quality on axis is about 200 lp/mm.

AGRINS are used where you want to correct aberrations of a lens in much the same way that an aspheric surface does, but without having to make and test aspherics. These are available in about 7 different base glass types which include crowns, high crowns and flints. Index of refraction changes up to 0.05 in the linear region of the axial gradient are possible. Depths up to 8 mm can be economical. The depth of the gradient must include the full SAG of the lens surface and therefore limits the diamter of the AGRIN lens. We have made AGRINS for use in imaging systems which are up to 75 mm in diameter.

Gradient Lens can make GRIN rods up to about 8 mm diameter. Our BigGRINS come standard in 3mm, 4mm and 5mm diameters with NA‰0.2 at 633nm. How close to 0.25P do you need to be? We do not have a way to measure the profile directly at 0.83um, so we would have to interpolate to get the proper length rods.

The EndoGRINS relays (manufactured by Gradient Lens Corporation) are quite different from the SELFOC relays manufactured by NSG. Similar sizes and lengths are available, however the chromatic properties are different. The EndoGRINS relays have a negative dispersion which tends to cancel the axial color introduced by positive lens groups which are often used as objective or CCD coupler lenses at each end of the relay. This leads to lower overall cost for systems and better images.

Ray tracing GRIN lenses

Zemax will allow GRIN lenses with the NSG formulas for index. I have had good luck modeling these. NSG will give you unprinted data if your lens is not in the database. You can use OSLO LT to evaluate the coupling efficiency vs. fiber tilt. You will need to enter the data for your Selfoc(tm) lens yourself, because NSG does not make the actual data for these lenses publically available. You may be satisfied with the paraxial data, which you can get from the NSG data sheet (tel 908-469-9650). You can obtain